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# Superpixels for Image Processing and Computer Vision

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## 1 Background and Motivation

Since the advent of digital images, pixels have served as the base elements of image processing tasks. However, pixels are only the result of the discrete acquisition and representation of images, and they do not represent any semantic entities. To address this issue, superpixel segmentation has been proposed, the aim of which is to oversegment the image by grouping pixels that share similar properties. This provides a grouping of pixels into perceptually meaningful entities that are more consistent with the human visual system and that can serve as primitives for further computation (see Figure 1).

Superpixels have become a key building block for many algorithms in image processing and computer vision, such as image segmentation, image parsing, semantic labeling, and object classification, detection, and tracking. Indeed, there are many benefits of working at the superpixel level instead of the classical pixel level. First, superpixels carry more information than pixels since they better adhere to the natural image boundaries than square patches. Second, superpixels have a perceptual meaning since pixels belonging to a given superpixel share similar visual properties. Third, superpixels provide a convenient and compact representation of images that can be very useful for computationally demanding problems, as a superpixel graph has many fewer nodes than the classical grid graph.

The aim of the special section is to present some of the cutting-edge works currently being done on and with superpixels and to reveal the challenges that still lie ahead.

## 2 Quick Facts about the Special Section

The guest editors suggested putting together this Special Section on Superpixels for Image Processing and Computer Vision to the editor-in-chief in November 2016. In January 2017, the first call for papers was issued. Between January and April 2017, many authors responded to the call for papers. After rigorous review between April and September 2017, 10 papers were finally accepted for inclusion in the special section. We hope that the reader will enjoy the interesting research works selected for the section.

## 3 Scanning the Special Section

The papers included in this special section provide a good coverage of the field and are illustrative of the variety of topics encountered in "Superpixels for Image Processing and Computer Vision," ranging from new superpixel methods, superpixel-based image segmentation, superpixel-based applications, and evaluation of superpixel methods.

### 3.1 *Superpixel Methods*

The special section includes two papers devoted to new superpixel methods. In their paper "Convex constrained meshes for superpixel segmentations of images," Forsythe et al. consider the problem of splitting a pixel-based image into convex polygons with vertices at subpixel resolution. They introduce a convex constrained mesh that accepts any straight line segments and outputs a complete mesh of convex polygons without small angles and with approximation guarantees for the given lines. The paper by Nakamura et al. is titled "Hierarchical image segmentation via recursive superpixel with adaptive regularity." They propose a fast and accurate segmentation algorithm in a hierarchical way based on a recursive superpixel technique. The latter is based on a superpixel energy formulation in which the trade-off between data fidelity and regularization is dynamically determined based on the local residual in the energy optimization procedure.

### 3.2 *Superpixel-Based Image Segmentation*

The special section also includes three papers that propose segmentation methods based on superpixels. In "Adaptive strategy for superpixel-based region-growing image segmentation," Chaibou et al. present a region-growing image segmentation approach based on superpixel decomposition. From an initial contour-constrained oversegmentation of the input image, the image segmentation is achieved by iteratively merging similar superpixels into regions. The paper of Borovec et al. on "Region growing using superpixels with learned shape prior" presents a region-growing approach on superpixels with learned statistical shape properties that is formulated as an energy minimization solved with graph cuts. Mathieu et al. propose, in their paper titled "A scalable superpixel-based interactive segmentation method," an interactive segmentation on superpixels formulated as a discrete energy minimization with a new regularization term that significantly reduces the required number of seeds. The consistency of the segmentation result regarding the image visual features and the seeds given by the user is obtained by a supervised learning stage.

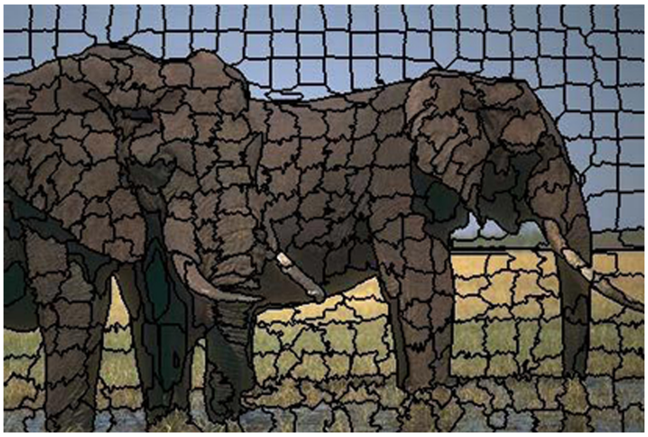

**Fig. 1** Example of superpixel segmentation.

### 3.3 *Superpixel-Based Applications*

Three papers are devoted to applications that make the most of a superpixel decomposition. In "Supervised and unsupervised segmentation using superpixels, model estimation, and Graph Cut," Borovec et al. propose a multiclass image segmentation method composed of three steps — computing superpixel-based features, calculating class probabilities and classifying superpixels with graph cuts. The interest of the approach is shown on several medical imaging datasets. In "Supervoxels for graph cuts-based deformable image registration using guided image filtering," Szmul et al. propose to address the problem of three-dimensional (3-D) deformable image registration for lung computed tomography. Their approach combines a supervoxel-based image representation with the concept of graph cuts as an efficient optimization technique for 3-D deformable image registration. In "Superpixel-based segmentation of glottal area from videolaryngoscopy images," Turkmen et al. propose an approach for the segmentation of glottal area from videolaryngoscopy images.

### 3.4 *Evaluation of Superpixel Methods*

Two papers consider the evaluation of superpixel methods. In "Robustness analysis of superpixel algorithms to blur, additive Gaussian noise and impulse noise," Brekhna et al. evaluate the robustness of eleven recently proposed algorithms to different types of noise. Finally, Giraud et al., in their paper titled "Evaluation framework of superpixel methods with a global regularity measure," introduce an evaluation framework that aims at unifying the comparison process of superpixel methods. To overcome the limitations of existing metrics, they base their evaluation on three core decomposition aspects—color homogeneity, respect of image objects, and shape regularity.


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